

Claims

- [c1] 1. An oligomer-modified anionically polymerized polymer comprising the reaction product of:
- (a) an oligomer polymerized from at least one monomer selected from the group consisting of vinyl aromatic monomers and epoxy functional monomers, the oligomer having a number average molecular weight of about 500 to about 10,000 g/mol and a weight average molecular weight of about 1000 to about 60,000 g/mol; and
 - (b) an anionically polymerized polymer.
- [c2] 2. The oligomer-modified anionically polymerized polymer of claim 1, wherein the oligomer has a number average molecular weight of about 1000 to 10,000 g/mol and a weight average molecular weight of about 1500 to 60,000 g/mol.
- [c3] 3. The oligomer-modified anionically polymerized polymer of claim 1, wherein the oligomer is polymerized from at least one additional free radically polymerizable monomer selected from the group consisting of anhydride functional monomers, ester functional monomers, and carboxylic acid functional monomers.

- [c4] 4. The oligomer-modified anionically polymerized polymer of claim 1, wherein the oligomer has a number average number of functional groups per chain, excluding ester functional groups, of no more than about 20.
- [c5] 5. The oligomer-modified anionically polymerized polymer of claim 1, wherein the oligomer has a solubility parameter from about 13 to 30.
- [c6] 6. The oligomer-modified anionically polymerized polymer of claim 1, wherein the anionically polymerized polymer comprises a polymer selected from the group consisting of polystyrene, polybutadiene, polyisoprene, and random, block or tapered copolymers made from monomers selected from the group consisting of styrene, butadiene, and isoprene.
- [c7] 7. The oligomer-modified anionically polymerized polymer of claim 1, wherein the anionically polymerized polymer has a number average molecular weight of about 3,000 to 300,000 g/mol.
- [c8] 8. The oligomer-modified anionically polymerized polymer of claim 1, wherein the anionically polymerized polymer has a number average molecular weight of about 20,000 to 300,000 g/mol.

- [c9] 9. The oligomer-modified anionically polymerized polymer of claim 1, wherein the anionically polymerized polymer is polymerized from at least one vinyl aromatic monomer and at least one conjugated diene molecule.
- [c10] 10. The oligomer-modified anionically polymerized polymer of claim 1, wherein the anionically polymerized polymer is polymerized from vinyl aromatic monomers and conjugated diene monomers in a molar ratio of vinyl aromatic monomer to conjugated diene monomer of about 0.1 to about 1.0.
- [c11] 11. The oligomer-modified anionically polymerized polymer of claim 1, wherein the anionically polymerized polymer is polymerized from conjugated diene monomers and has a content of 1,2- structures from about 8 to 70 mole %.
- [c12] 12. The oligomer-modified anionically polymerized polymer of claim 1, wherein the oligomer-modified anionically polymerized polymer has a percentage of coupled chains from about 2 to 90 mole %.
- [c13] 13. The oligomer-modified anionically polymerized polymer of claim 1, wherein the oligomer-modified anionically polymerized polymer has a number average molecular weight from about 5,000 to 1,000,000 g/mol.

- [c14] 14. The oligomer-modified anionically polymerized polymer of claim 1, wherein the oligomer is polymerized from vinyl aromatic and epoxy functional monomers.
- [c15] 15. The oligomer-modified anionically polymerized polymer of claim 1, wherein the reaction product comprises about 0.1 to 40 wt.% oligomer based on the total amount of reacted oligomer and anionically polymerized polymer.
- [c16] 16. The oligomer-modified anionically polymerized polymer of claim 15, wherein the anionically polymerized polymer is a thermoplastic having a number average molecular weight of about 3,000 to 50,000 g/mol.
- [c17] 17. The oligomer-modified anionically polymerized polymer of claim 16, wherein the oligomer is polymerized from about 1 to 60 mole % epoxy-functional or carboxylic acid-functional monomers.
- [c18] 18. The oligomer-modified anionically polymerized polymer of claim 1, wherein the reaction product comprises about 0.1 to 5 wt.% oligomer based on the total amount of reacted oligomer and anionically polymerized polymer.
- [c19] 19. The oligomer-modified anionically polymerized

polymer of claim 18, wherein the anionically polymerized polymer is a thermoplastic having a number average molecular weight of about 20,000 to 100,000 g/mol.

[c20] 20. The oligomer-modified anionically polymerized polymer of claim 19, wherein the anionically polymerized polymer comprises a polymer selected from the group consisting of polystyrene, polybutadiene, polyisoprene, and random, block or tapered copolymers made from monomers selected from the group consisting of styrene, butadiene, and isoprene.

[c21] 21. The oligomer-modified anionically polymerized polymer of claim 18, wherein the oligomer is polymerized from about 0.5 to 60 mole % epoxy-functional or carboxylic acid-functional monomers.

[c22] 22. The oligomer-modified anionically polymerized polymer of claim 15, wherein the anionically polymerized polymer is a thermoplastic having a number average molecular weight of about 5,000 to 40,000 g/mol.

[c23] 23. A method for preparing an oligomer-modified anionically polymerized polymer, the method comprising reacting an anionically polymerized polymer with an oligomer polymerized from at least one monomer selected from the group consisting of vinyl aromatic

monomers and epoxy functional monomers, the oligomer having a number average molecular weight of about 500 to about 10,000 g/mol and a weight average molecular weight of about 1000 to about 60,000 g/mol.

[c24] 24. The method of claim 23, wherein the oligomer is polymerized in a reactor using a continuous polymerization process at a polymerization temperature of from about 180°C to about 350°C with a residence time in the reactor of less than about 60 minutes.

[c25] 25. The method of claim 23, wherein the oligomer is reacted with the anionically polymerized polymer in the same reaction zone where the anionically polymerizable polymer is polymerized.

[c26] 26. The method of claim 23, wherein the anionically polymerized polymer is polymerized in a first reaction zone and reacted with the oligomer in a second reaction zone.

[c27] 27. The method of claim 23 comprising polymerizing the anionically polymerized polymer, adding a sufficient amount of terminating agent to deactivate a portion of the living chains in the anionically polymerized polymer and reacting at least some of the remaining living chains with the oligomer.

[c28] 28. The method of claim 23, wherein the molar ratio of oligomer to anionically polymerized polymer in the reaction is between 0.02 and 1.

[c29] 29. The method of claim 23, wherein reacting the anionically polymerized polymer with the oligomer comprises coupling anionically polymerized polymer with the oligomer and further wherein the average number of anionically polymerized polymer chains reacted with an oligomer is about 2 to 30.

[c30] 30. The method of claim 29, wherein about 2 to about 90 mole % of the anionically polymerized polymer undergoes coupling reactions.

[c31] 31. The method of claim 23, wherein reacting the anionically polymerized polymer with the oligomer comprises end-capping anionically polymerized polymer with oligomer and further wherein at least 10 mole % of the anionically polymerized polymer undergoes end-capping reactions.

[c32] 32. A polymer composition comprising:
(a) the oligomer-modified anionically polymerized polymer of claim 1; and
(b) a linear anionically polymerized polymer.

- [c33] 33. The polymer composition of claim 32, wherein the linear anionically polymerized polymer comprises a portion of the anionically polymerized polymer that has been deactivated by a terminating agent.
- [c34] 34. The polymer composition of claim 33, wherein the linear anionically polymerized polymer makes up about 10 to 90 mole % of the polymer composition.
- [c35] 35. A reinforced material comprising the oligomer-modified anionically polymerized polymer of claim 1 mixed with a material to be reinforced.
- [c36] 36. The reinforced material of claim 35, wherein the material to be reinforced is selected from the group consisting of asphalt, plastics and rubbers.
- [c37] 37. The reinforced material of claim 35, wherein the reinforced material is a plastic selected from the group consisting of polyamides, polyurethanes, polyethers, polysulfones, polyether-ketones, polyetherether ketones, polyimides, polyetherimides, polycarbonates, polyesters, polystyrene and copolymers thereof.
- [c38] 38. An article made from the reinforced material of claim 35.
- [c39] 39. The article of claim 38, wherein the article is an ex-

truded article, an injection molded article, a compression molded article or a tire.

- [c40] 40. A modified asphalt comprising asphalt mixed with the oligomer-modified anionically polymerized polymer of claim 1.
- [c41] 41. The modified asphalt of claim 40 comprising about 1 to 15 wt.% of the oligomer-modified anionically polymerized polymer based on the total weight of the asphalt and the oligomer-modified anionically polymerized polymer.
- [c42] 42. The modified asphalt of claim 40 comprising about 5 to 20 wt.% of the oligomer-modified anionically polymerized polymer based on the total weight of the asphalt and the oligomer-modified anionically polymerized polymer.
- [c43] 43. A modified asphalt comprising asphalt mixed with the polymer composition of claim 32.
- [c44] 44. The modified asphalt of claim 43 comprising about 1 to 20 wt.% of the polymer composition based on the total weight of the asphalt and the polymer composition.
- [c45] 45. An adhesive composition comprising the oligomer-modified anionically polymerized polymer of claim 1,

wherein the reaction product comprises about 0.05 to 5 wt.% oligomer based on the total amount of reacted oligomer and anionically polymerized polymer.

- [c46] 46. The adhesive composition of claim 45, wherein the oligomer is polymerized from about 0.5 to 30 mole % epoxy functional monomer.
- [c47] 47. The adhesive composition of claim 45, wherein the oligomer is polymerized from about 10 to 75 mole % vinyl aromatic monomer.
- [c48] 48. The adhesive composition of claim 45 further comprising at least one additive selected from the group consisting of tackifiers, stabilizers, plasticizers and antioxidants.
- [c49] 49. The adhesive composition of claim 45 comprising about 15 to 30 wt.% oligomer-modified anionically polymerized polymer, about 45 to 60 wt.% tackifier, about 15 to 30 wt.% plasticizer and about 0.05 to 2 wt.% antioxidant.
- [c50] 50. A modified plastic comprising a plastic mixed with the oligomer-modified anionically polymerized polymer of claim 1, the mixture comprising about 1 to 15 wt.% oligomer-modified anionically polymerized polymer based on the total weight of the oligomer-modified an-

ionically polymerized polymer and the plastic.

- [c51] 51. The modified plastic of claim 50, wherein the plastic comprises a polymer selected from the group consisting of polystyrene, polybutadiene, polyisoprene, and random, block or tapered copolymers made from monomers selected from the group consisting of styrene, butadiene, and isoprene and having a number average molecular weight of about 3,000 to 300,000 g/mol.
- [c52] 52. The modified plastic of claim 50 wherein the reaction product comprises about 0.1 to 33 wt.% oligomer based on the total amount of reactor oligomer and anionically polymerized polymer.
- [c53] 53. The modified plastic of claim 52, wherein the oligomer comprises about 0.5 to 50 mole % epoxy-functional, anhydride-functional or carboxylic acid-functional monomer.
- [c54] 54. The modified plastic of claim 50, wherein the anionically polymerized polymer comprises a polystyrene.
- [c55] 55. The modified plastic of claim 50, wherein the mixture comprises about 1 to 10 wt.% oligomer-modified anionically polymerized polymer based on the total weight of the oligomer-modified anionically polymerized polymer and the plastic.

- [c56] 56. The modified plastic of claim 52, wherein the reaction product comprises about 10 to 30 wt.% oligomer based on the total amount of reacted oligomer and anionically polymerized polymer.
- [c57] 57. The modified plastic of claim 56, wherein the anionically polymerized polymer comprises a polystyrene.
- [c58] 58. The modified plastic of claim 50, wherein the plastic is selected from the group consisting of polyamides, polyurethanes, polyethers, polysulfones, polyether-ketones, polyetherether ketones, polyimides, polyetherimides, polycarbonates, polyesters, polystyrene and copolymers thereof.
- [c59] 59. The modified plastic comprising a plastic mixed with the oligomer-modified anionically polymerized polymer of claim 22, wherein the modified plastic comprises about 1 to 10 wt.% of oligomer-modified anionically polymerized plastic based on the total weight of the plastic and the oligomer-modified anionically polymerized polymer.